INDOOR AIR QUALITY ASSESSMENT

Hopedale Middle/High School
Classroom 227
25 Adin Street
Hopedale, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment

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Background/Introduction

At the request of Leonard Izzo of the Hopedale Health Department, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at Hopedale Junior/Senior High School.

On May 9, 2002, a visit was made to this school by Cory Holmes, Environmental Analyst of the Emergency Response/Indoor Air Quality (ER/IAQ) program, BEHA, to conduct an indoor air quality assessment. Mr. Holmes was accompanied by Mr. Izzo and Phil Rinehart, Director of Buildings and Grounds, Hopedale School Department (HSD). The school was previously visited by BEHA on March 20, 2000 to investigate concerns about pollutants generated by renovation activities and a report was issued (MDPH, 2000a). The BEHA also issued a letter describing conditions of a flammable storage cabinet (MDPH, 2000b) and a subsequent report detailing general indoor air quality conditions in the school not directly related to the renovation/construction activities (MDPH, 2000c).

The purpose of the most recent visit was to investigate possible causes of increased symptoms experienced by a building occupant in classroom 227. Classroom 227 is on the second floor of the old wing, which has been completely renovated. These renovations included new heating, ventilation and air conditioning (HVAC) equipment, new floor tile, drop ceilings and other interior work. Classroom 227 served as a computer room during the 2000-2001 academic school year and currently serves as a health education room. Classroom 227 is an interior room and does not have openable windows.

Methods

In addition to visual inspection for potential allergens/asthmagens, microbial growth and/or water damaged building materials, BEHA staff conducted a series of tests for general indoor air quality. Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). Outdoor TVOC levels were taken as comparison values to indoor levels. Air tests for ultrafine particulates were taken with the TSI, P-Trak ™ Ultrafine Particle Counter Model 8525.

Results

The school has a student population of approximately 400 and a staff of approximately 65. Tests were taken in classroom 227 and several other areas in the school for comparison. The tests were taken during normal operations at the school. Test results appear in Tables 1-2.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were below 800 parts per million (ppm) in classroom 227, indicating adequate airflow in this area of the school. However, this room was empty at the time of the investigation, therefore carbon dioxide levels do not reflect those that would be expected with occupancy.

Fresh air is provided to the classrooms by a rooftop air-handling unit (AHU) and ducted to classrooms via ceiling-mounted air diffusers (see Pictures 1 & 2) located to the rear of the classroom. Mr. Rinehart reported that the HSD's HVAC contractor had recently adjusted the damper for the rooftop AHU to maximize outside air intake. Exhaust air is provided by return vents located at the front of each classroom which are identical to the supply diffusers shown in Picture 2. This system was functioning during the assessment.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that HVAC systems be re-balanced every five years (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix I of this assessment.

Temperature measurements ranged from 68 ^{o} F to 72 ^{o} F, which were within or close to BEHA's recommended comfort range of 70 ^{o} F to 78 ^{o} F. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building ranged from 33 to 35 percent, which was below the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

In order for building materials to support mold growth, a source of water is necessary. Identification and elimination of moisture is necessary to control mold growth. The BEHA assessment occurred after several days of intermittent rain. At the time of the BEHA assessment no evidence of standing water, water stains, visible mold growth or associated odors were observed in classroom 227. In addition, no water damaged ceiling tiles, building materials or other evidence of water penetration was observed in the classroom ceiling plenum.

Ultrafine Particulates (UFPs) and TVOCs

The combustion of fossil fuels can produce particulate matter that is of a small diameter (<10 μm), which can penetrate into the lungs and subsequently cause irritation. For this reason a device that can measure particles of a diameter of 10 μm or less was used to identify any potential sources of these pollutants. Inhaled particles can cause respiratory irritation. VOCs, which are commonly found in cleaners, paints, mastics and many other materials, can also be a source of eye and respiratory irritation. Tests were taken in order to determine if any unusual presence of TVOCs or UFPs were present. No measurements of UFPs or TVOCs were observed above background levels (see Tables), indicating that no unusual sources of VOCs or UFPs were present.

Other Concerns

The main symptoms reported were eye and respiratory irritation. There are several inter-related issues that can contribute to this complaint. A likely cause of eye irritation is the accumulation of dust on flat surfaces. The room contained a number of flat surfaces upon which dust can acuumulate (see Picture 3). A light coating of dust was observed on these flat surfaces with heavier accumulation to the rear of the classroom below supply air diffusers and on computer equipment (see Picture 4). Household dust can be irritating to eyes, nose and respiratory tract.

Increasing the intake of outside air can also allow more airborne particulates (e.g. dirt, dust and pollen) into the system. AHUs are equipped with filters that strain particulates from airflow. According to Mr. Rinehart the manufacturer of the AHU recommends changing filters twice a year; the HSD changes filters four times a year. The type of filters installed provide minimal filtration of respirable dusts (see Picture 5). In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent (Minimum Efficiency Reporting Value equal to 9) would be sufficient to reduce many airborne particulates (Thornburg, D., 2000; MEHRC, 1997; ASHRAE, 1992). Note that increasing filtration can reduce airflow (called pressure drop), which can subsequently reduce the efficiency of the AHU due to increased resistance. Prior to any increase of filtration, each AHU should be evaluated by a ventilation engineer to ascertain whether it can maintain function with more efficient filters.

Finally, classrooms contain dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), (e.g. methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Continue with current filter changing procedures. Consider increasing the dust-spot efficiency of HVAC filters. Prior to any increase of filtration, each piece of air handling equipment should be evaluated by a ventilation engineer as to whether it can maintain function with more efficient filters.
2. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
3. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

References

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Picture 1

Rooftop AHU Providing Ventilation to Classroom 227

Picture 2

Supply Air Diffuser for Classroom 227

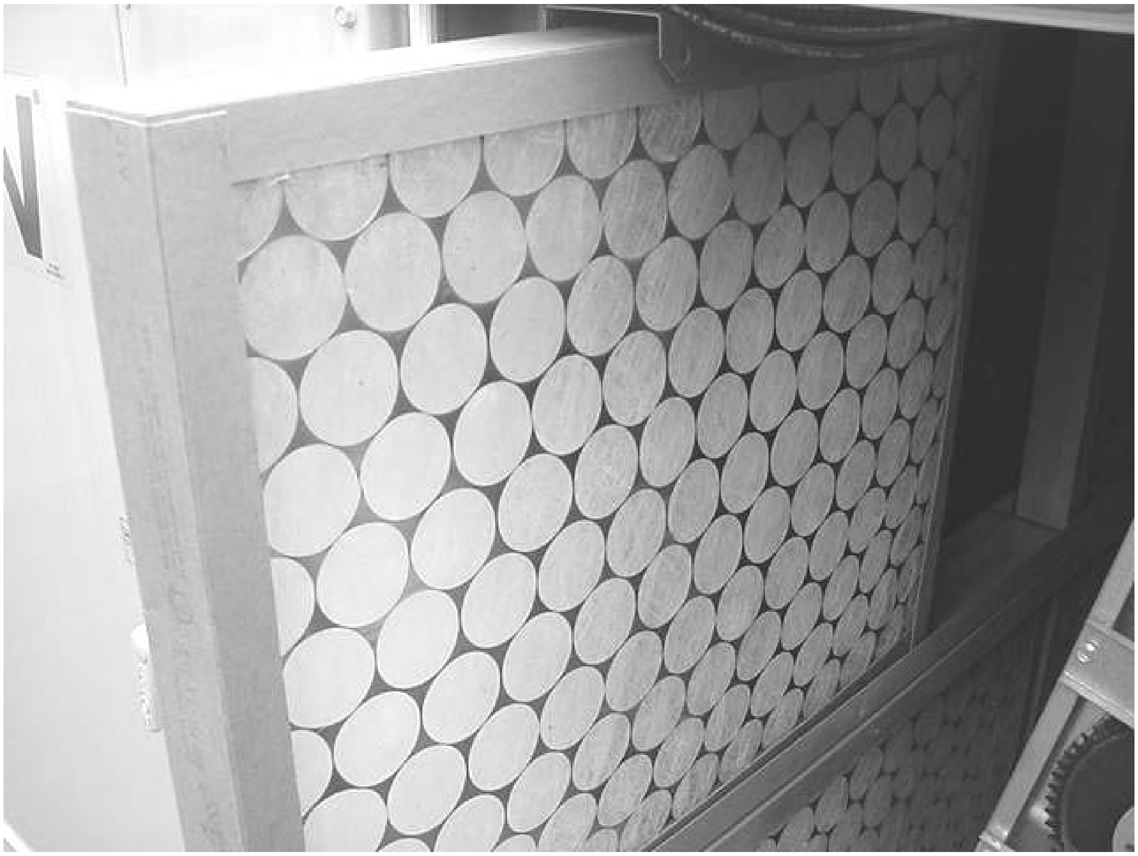
Picture 3

Interior of Classroom 227, Note Room is Well-kept and Clutter is Minimal

Picture 4

Accumulated Dust Smudged on Computer Equipment to the Rear of Classroom 227

Picture 5



Fibrous Mesh Filter Installed in Rooftop AHU Providing Minimal Filtration

TABLE 1

Indoor Air Test Results – Hopedale Jr/Sr High School, Hopedale, MA – May 9, 2002

Location	Carbon Dioxide *ppm	Carbon Monoxide *ppm	TVOCs *ppm	Ultrafine Particulates p/cc	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Outside (Background)	423	0		13,000-16,800	67	34					Weather conditions: cloudy, cool, light breeze
Room 227 (center)	506	0	0.0	8,600	68	33	0	No	Yes	Yes	
Room 227 (at elec. outlet)	510	0	0.0	8,400	69	33	0				
Room 227 (East return vent)	516	0	0.0	8,100	69	34	0				Vent on
Room 227 (East supply vent)	510	0	0.0	10,700	70	33	0				Vent on
Room 227 (West supply vent)	509	0	0.0	11,000	69	33	0				Vent on
Room 227 (West return vent)	508	0	0.0	8,500	69	34	0				Vent on
Room 227 (around café windows)	510	0	0.0	8,500	70	33	0				
Rooftop											RTU5C-AHU, interior clean, no [illegible]

*** ppm = parts per million parts of air**

CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Hopedale Jr/Sr High School, Hopedale, MA – May 9, 2002

Location	Carbon Dioxide *ppm	Carbon Monoxide *ppm	TVOCs *ppm	Ultrafine Particulates p/cc	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
									Intake	Exhaust	
											standing water on roof in or near AHU, fibrous mesh filters
245 Multi-Purpose Room	490	0	0.0	6,900	68	35	3	No	Yes	Yes	Adjacent to Room 227, stained ceiling tiles due to hot water pump leak-repaired
223	714	0	0.0	9,200	72	33	22	Yes	Yes	Yes	Door open
118	614	0	0.0	8,700	72	30	12	Yes	Yes	Yes	Door open, 20 + computers, carpeted, dust accumulation on flat surfaces

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